UNITED NATIONS

GENERAL ASSEMBLY

Distr.
GENERAL

A/AC.105/552
4 November 1993

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

# REPORT ON THE THIRD UNITED NATIONS TRAINING COURSE ON REMOTE-SENSING EDUCATION FOR EDUCATORS, HELD IN COOPERATION WITH THE GOVERNMENT OF SWEDEN

(Stockholm and Kiruna, Sweden, 3 May-4 June 1993)

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V.93-89856T

# INTRODUCTION

## A. Background and objectives

1. At its thirty-seventh session, the General Assembly adopted resolution 37/90 of 10 December 1982, in which it endorsed the recommendation of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) that the United Nations Programme on Space Applications should promote the growth of indigenous nuclei and an autonomous technological base in space technology in developing countries.

2. The Committee on the Peaceful Uses of Outer Space, at its thirty-fifth session in June 1992, endorsed the activities of the United Nations Programme on Space Applications for 1993 as proposed by the Expert on Space Applications and as recommended by its Scientific and Technical Subcommittee at its twenty-eighth session. Subsequently, the General Assembly, by its resolution 47/67 of 14 December 1992, endorsed the activities of the Programme on Space Applications for 1993.

3. In response to Assembly resolution 46/45 and in accordance with the UNISPACE 82 recommendations, the Programme on Space Applications included, as one of its 1993 activities, the organization of a training course on remote-sensing education for educators.

4. The Third United Nations International Training Course on Remote-Sensing Education for Educators was organized in cooperation with the Government of Sweden through the Swedish Agency for International Technical and Economic Cooperation (BITS) and hosted by Stockholm University and the Swedish Space Corporation (SSC Satellitbild) for the benefit of developing countries.

5. The main objectives of the course were to provide educational and practical experience to participants of current and future remote-sensing systems, including the acquisition, processing, interpretation, applications and archiving of the data generated by such systems, as well as to equip them with the ability to introduce elements of the technology, as appropriate, in the educational curricula in their universities and institutes.

6. The participants expressed their appreciation to the United Nations and the Government of Sweden for organizing and hosting the course, for their financial assistance and for the technical quality of the course. Participants will report to the appropriate authorities in their own countries.

## B. Organization of the course

7. The course was held at Stockholm and Kiruna from 3 May to 4 June 1993. Welcoming and keynote addresses were given by Mr. S. Pettersson of BITS, on behalf of the Government of Sweden and the Expert on Space Applications from the United Nations Office for Outer Space Affairs. The programme of the course (contained in the annex) was designed jointly by the United Nations Office for Outer Space Affairs, Stockholm University and SSC Satellitbild.

8. Participating in the course were 26 persons from Bangladesh, Bolivia, Chile, Costa Rica, Ecuador, Federal States of Micronesia, Ghana, Jordan, Kenya, Madagascar, Malawi, Malaysia, Mauritius, Nepal, Nigeria, Sri Lanka, Thailand, Uganda, Uruguay, Venezuela, Viet Nam and Zimbabwe.

9. Funds allocated by the United Nations were used to defray the costs of international air travel for 12 participants. The Government of Sweden provided room and board, local transportation and pocket money for all the participants, as well as international travel expenses for 14 participants.

10. The presentations at the course provided participants with a basic understanding of the development and use of remote-sensing technology in natural-resource management and environmental assessment; they were also aimed at equipping them with the ability to serve as a focal point in their own countries and to introduce elements of the technology, as appropriate, into the educational curricula in their universities and educational institutions.

11. A number of lecturers and participants made presentations, including case-studies of projects or programmes in which they were involved conducted in countries of Africa, Asia and Latin America as well as remote-sensing research and training applications in developing countries.

12. Some of the presentations clearly demonstrated that the use of remote-sensing techniques had an impact on decision- and policy-making. Other presentations in which participants used data and satellite imagery from their own countries, provided an overview of remote-sensing applications with an emphasis on case-studies: principles of visual and digital image analysis; and use of Geographic Information Systems (GIS) in different fields of applications.

13. Numerous practical exercises were organized in order to provide the participants with the opportunity for hands-on training in the visual interpretation of remote-sensing data. The course was supplemented by on-site visits to the SSC Satellitbild and European Space Agency (ESA) ground stations, and SSC facilities and laboratories at Satellitbild, Kiruna.

## I. SUMMARY OF THE COURSE

### A. Remote sensing and global change

14. Advances in measurement technology, particularly satellite-borne remote sensing, allow global monitoring of the environment. New generations of computers have increased the capability to synthesize data sets and to develop increasingly comprehensive numerical models. These tools, coupled with the growing understanding of the components of the Earth system, the atmosphere, oceans, soil and solid earth, and the physical, chemical and biological processes that link them, permit an integrated and interdisciplinary approach to Earth-system studies.

15. Traditionally, monitoring environmental changes is done either by ground surveys or aerial photo-interpretation and these changes are normally detected by a manual comparison of a single-data analysis. For large areas, however, both ground surveys and aerial photo-interpretation methods are impractical due to the large amount of data to be collected and processed, and to improper data handling. Remote sensing, with its big area coverage and short repetitive cycle of capabilities, offers a new and effective alternative. In addition, the digital nature of the data collected makes computer processing possible, which is an advantage in handling a large volume of data.

16. Throughout the years, various methods for detecting environmental changes using remote-sensing techniques have been developed and successfully tested. Space technology has become operational and is being used widely in many countries for resource management and environmental applications. Various case-studies and projects have shown that remote sensing contributes significantly to economic and social development and to an understanding of global change. Currently, all parts of the world are being monitored by Earth Observation Systems (EOS). As the data sets obtained by such sensor systems may represent the only reliable information on a given country, such information is an indispensable element in developing environmental models and data-management systems for the country in question. These models and systems are crucial to understanding and safeguarding the environment as well as to ensuring a more effective management of natural resources at both national and global levels.

17. The latest contribution to the observation of the Earth from space is the microwave-sensor system. This system can function in the dark and can penetrate rain and clouds, thus enhancing the possibilities of obtaining information from cloud-covered areas. Examples of space systems are the European Remote Sensing Satellite (ERS) of ESA, the Japanese Earth Resources Satellite (JERS) and the forthcoming RADARSAT of Canada. Observation of the Earth from space will not only continue but also will be intensified.

18. Remote sensing technology is a multidisciplinary tool. It has many proven applications, particularly in natural-resources management, environmental assessment, disaster mitigation, search-and-rescue missions and the monitoring of drug-related plants. Information obtained from data acquired by EOS can be used as a basis for decision-making as well as a means for monitoring the outcome of decisions. It can provide opportunities for a country to tailor its development activities to its resource base. Such information can also provide a country with the opportunity to enter into mature mutually beneficial resource-exploitation relationships, particularly with other countries. Because observation of the Earth from space can be used for crop forecasting in particular, it provides opportunities for economic bargaining and food-security management.

19. The availability of such data will assist the international community to gain a better understanding of how to safeguard the global environment as well as to ensure a more efficient management and productive harnessing of the natural resources of the planet. Major global programmes such as the International Geosphere-Biosphere Programme (IGBP) and Mission to Planet Earth will contribute to the understanding of global change. However, a prerequisite for the effective participation of all countries in international programmes as well as in national and regional projects is an adequate and long-term commitment to and investment in the development of skills and knowledge in the discipline at the local level.

## B. Limitations and potential in developing countries

20. During the initial phases of satellite remote sensing it was postulated, especially within the academic community, that the large quantities of data produced by the satellite sensors would call for a computerized approach to both the analysis of data and the production of thematic maps. Especially in the developing world, satellite remote sensing seemed to represent a short-cut to creating accurate and updated inventories of natural resources and environmental monitoring. Centres for digital data and image analysis were established in many countries, often tied to national mapping agencies, with the aim of supporting national natural-resources inventories.

21. Analysis of a number of applied projects, however, revealed only a limited advancement of the digital-image interpretation technique and associated production of thematic maps. The reason was not the technology as such, but the complexity of the object under study. Classification of data, application of statistical methods and perhaps a new colouring of the satellite scene cannot produce a true and reliable thematic map, in spite of the fact that one of the popular satellite sensors is called the "Thematic Mapper" (TM). In the best of cases, computer manipulation can enhance disparate spectral signatures in the satellite image in order to help the analyst find and interpret what has been recorded by the sensor system. Other image properties that help to detect and identify different features, such as tonal change and spatial arrangement, are seldom taken into account.

22. One major factor behind this limited practical use may be a lack of balance between the push for computer-based, high-tech approaches and more appropriate low-tech methods. In a regional or national inventory, the digital approach can hardly be applied for thematic map production as the environmental variation calls for a constantly renewed calibration of field data, within and between the satellite scenes, as well as between registrations from different seasons. It should be realized that the profession of image interpretation expert does not exist, rather there are experts on different subjects that are also good at image interpretation.

23. The over-emphasis on computer-based handling of satellite data and the concentration of all resources and competence at single, national centres are likely to hinder and seriously delay the vast amount of development work that is necessary to find suitable methods of applying a practical application of the technology. The analysis of satellite data is a highly sophisticated technology that requires large and advanced computer resources. As long as such attitudes prevail in national centres, it is unlikely that the application of satellite information will be transferred from the satellite data laboratory to users at local levels.

24. Hopefully therefore, development of satellite data will follow paths similar to the development of computers. At the advent of computers only a few computer centres existed, which were managed by highly qualified technical specialists; currently personal computers have become useful everyday tools for almost everyone in the industrialized world.

25. To make effective and rewarding use of satellite remote sensing in a developing country in the near future, methods should be introduced and applied that: (a) can have an immediate impact; (b) become operational rapidly; (c) require only a short period of training; (d) require only limited investment; and (e) can be applied not only on a central level but also regionally or even locally.

26. In the future, satellite data will be distributed in formats and on media that can be read and analysed by low-cost personal computers at regional and local levels, i.e. where most of the practical work and field inventories are made. At present, however, satellite data can easily be distributed as images for use at those levels as it is possible to fulfil many of the requirements listed above if much the same technique and instrumentation that is used for studies of aerial photographs is applied also for the analysis of satellite images.

27. As aerial photography has been used in all developing countries for a long time for topographic mapping, land-use and soil conservation planning etc., there exists a local competence in its various techniques. Most authorities and institutions working with aerial photographs are usually well-equipped with viewing equipment, such as stereoscopes and stereo plotters, and are therefore also well-suited for study of satellite images. If necessary, the satellite data vendors can also tailor images to fulfil the demands of the client, but leave the image interpretation itself to the real experts, the end-users.

28. The training needed for satellite image analysis is mainly to familiarize local staff who have a basic degree in their field of expertise with the new types of image the satellite systems provide. Such people are usually eager to absorb and utilize relevant parts of the new technology in order to solve problems in their work. They are familiar with the region they are working in, its topography, geology, land-use pattern, cultivation practices etc., all factors that will be of great importance during the analysis of satellite images. This experience equips them with a new dimension in planning and enables staff at the district, regional or central level to identify problems and potential, and to reach their own decisions on the necessary action to be taken.

29. Past experience of applied satellite remote sensing in developing countries has so far confirmed that the visual interpretation of standard or enhanced image products is the most rewarding path to follow if the intention is to obtain appropriate results by rapidly utilizing the local expertise involved in practical project work.

### C. An approach to an applied remote-sensing training strategy in a developing country

30. Up-to-date, reliable and readily renewable information on land, in the broadest sense, is a prerequisite for the effective planning and administration of natural and human resources. There is an increasing awareness in developing countries of the important role that remote-sensing techniques in the form of aerial photography and satellite imagery will play in this context. The data that can be extracted from remote-

sensing imagery, using a wide range of techniques of different levels of sophistication, is multisectoral and can be used for land-use planning and environmental protection, forestry and agriculture, for geological- and mineral-exploration purposes, for water-resources inventories, for communication, for mapping and for environmental monitoring.

31. In most countries, the need for this technology is well understood and demands for its further implementation are growing. Considerable investment has been made in aerial photography during the past few decades and it can be anticipated that full coverage by satellite imagery of a national territory has been or will be acquired. The major constraints on a wider and more efficient use of remote-sensing techniques are: (a) the lack of knowledge of the realistic potential of these techniques at the decision-making level; (b) the limited number of trained specialists; and (c) the lack of trained technicians at the local level.

32. There is a need for a three-level training programme aimed at the following groups: (a) managers: heads of agencies, heads of departments and decision makers, which should include also participants from non-technical groups; (b) specialists who have already worked with remote-sensing techniques and who have a basic knowledge of the scientific background of this technology; and (c) technicians, with emphasis on local-level staff. The latter group has usually a very limited knowledge of remote sensing but can be expected to become the most active users of the technique.

33. Three packages can be envisaged, tailored to meet the needs of the three target groups. It will be necessary to prepare exhibition materials, manuals and compendiums, and audio-visual materials.

34. The course for managers should comprise an overview of the remote-sensing concept and of remote-sensing techniques and a presentation of current applications and future possibilities. Concrete examples of applications in the country concerned should be given together with general cost-benefit data. A question-and-answer technique should be encouraged. The exhibition will be a valuable presentation tool. Other audio-video possibilities should be considered.

35. The course for the specialists should be aimed at broadening and deepening their knowledge of remote sensing beyond the current national level of technology towards more efficient image-analysis systems. There should be a balance between theory and practical exercises. As it is hoped that several of the specialists can teach in the training courses for technicians, emphasis should be placed on teaching methods. The course should include the remote-sensing concept, aerial photography methods, basic photogrammetry, photo-interpretation, satellite imagery and image analysis, image interpretation and mapping from satellite imagery, presentation of the results of photo-interpretation and image analysis, comparisons of classical and satellite methods, and the economics of remote sensing.

36. The course for technicians should be a simplified variant of the one for specialists customized to meet practical requirements. These courses might be organized as follows:

Managers: One- or two-day seminar given once a year.

Specialists: Three-week course. A certain amount of customization will be carried out to meet specific sector interests.

Technicians: Two-week course with staff mainly recruited from the specialist group.

Apart from these three types of course, on-the-job training should also be emphasized.

## D. Remote-sensing satellite systems

### 1. Landsat system

37. Data and images from the Landsat system have been available since 1972. The result has been that most areas of the world are now well covered, with several images taken over the same areas at different times of year. This repeated, or multitemporal, coverage is one of the important advantages of the system as it will permit early detection and monitoring of potential environmental hazards as well as season-dependent changes in farming, natural vegetation etc.

38. Another characteristic of great importance, compared to conventional aerial photography, is the multispectral capabilities of the sensor systems on board the satellite. Instead of being limited to acquiring images of the scene in the visible and near infrared region of the electromagnetic (EM) spectrum, as with camera and film, the Landsat multispectral system records images from several bands of the visual, near and thermal infrared regions. Analysis of an image obtained in a specific part of the spectrum, or combinations from two or more bands (images), can help to differentiate between terrain features and details, which otherwise would be difficult to separate. The wavelength band intervals for two of the Landsat sensor systems, the Multi-Spectral Scanner (MSS) and TM, are indicated in the table below. The spatial resolution of the images obtained by the MSS sensor is 80 metres, while the resolution of the TM sensor is 30 metres.

Wavebands for Landsat and SPOT detectors

| | Landsat | | SPOT | |
|---|---|---|---|---|
| Band No. | MSS | TM | SX | P |
| 1 | 0.5-0.6 | 0.45-0.52 | 0.50-0.59 | 0.51-0.73 |
| 2 | 0.6-0.7 | 0.52-0.60 | 0.62-0.68 | |
| 3 | 0.7-0.8 | 0.63-0.69 | 0.79-0.89 | |
| 4 | 0.8-1.1 | 0.76-0.90 | | |
| 5 | | 1.55-1.75 | | |
| 6 | | 10.4-12.5 | | |
| 7 | | 2.08-2.55 | | |

### 2. SPOT system

39. The SPOT satellite system is in many aspects similar to the Landsat system. It has similar multispectral and multitemporal characteristics as well as the potential of large-area coverage.

40. A notable difference is the capability of SPOT to provide images of the same area obtained from consecutive orbits. While Landsat only gives a flat representation of the land surface directly below the satellite, SPOT can be programmed to view the same area during its next three orbits. This allows the construction of a quasi-stereoscopic image that can be utilized for topographic mapping. Recent studies

indicate that it is possible to produce topographic ortho-photo maps to the scales of 1:50,000 and larger, with contour intervals of 20 metres, by direct measurements based on the digital-image data.

41. Images of the Earth are obtained by SPOT with a resolution of 20 metres in its multispectral mode and 10 metres in its panchromatic mode. However, the higher resolution of the SPOT system leads to an increase of up to nine times in the number of picture elements to be handled per unit. To be able to handle all these data, the size of the scene has been reduced to approximately one tenth of that of the Landsat MSS scene, or 3,600 $km^2$. More SPOT images will be required to cover the same area as that covered by Landsat and the cost will be higher.

### 3. Landsat standard products

42. Overview images, also called "quick-looks", can be ordered as small-scale paper prints from Landsat images to check cloud cover and to identify geographical location. Quick-looks are MSS products but cover the same areas as the simultaneously obtained TM images.

43. Full-resolution images can be ordered as paper or film print in black-and-white or in colour. The spectral bands can be chosen for specific purposes and can be combined in a colour composite. Due to the increased number of pixels in the corresponding TM images, TM photography products are processed only in quarter-image scenes. The most common scale of the MSS film originals is 1:1,000,000, while for TM film products it is 1:500,000 (quarter scene).

44. MSS and TM data in digital form are delivered as full scenes with all spectral bands or a single spectral band. TM data can also be ordered covering only a quarter of the full MSS scene. Data are delivered either in raw form or corrected for radiometrical variations and geometrical distortions.

### 4. Standard SPOT products

45. Standard SPOT products comprise entire scenes or parts of scenes. A scene corresponds to a terrestrial area with a length of 60-80 km and a width of 60 km, depending on whether the image is obtained vertically or looking to the side. The scenes are identified on a predetermined grid on the Earth's surface and with latitude and longitude.

46. Standard products can be ordered at three levels of processing:

Level 1A. This is basically raw (unprocessed) data. Information from the detectors has been processed to normalize each spectral band. Coefficients for calibration between bands and absolute values are specified. No geometrical correction is included. The instrument's viewing angle is specified. This level of processing is particularly suitable for basic radiometric studies and stereo projections;

Level 1B. The data have been corrected for systematic errors with regard to radiometry and geometry, and to account for the Earth's rotation and curvature and angle of registration;

Level 2. A geometrically precision-corrected product. In addition to the radiometric correction in level 1B, the image has been corrected on the basis of maps or ground-control points and presented in an optional cartographic projection. Processing is done without a digital terrain model. This means that for areas with a relatively low relief and almost vertical view angles, a positional accuracy of 5 metres can be achieved in the case of panchromatic images and 10 metres for multispectral images.

### 5. Special SPOT products

47. In addition to the above-mentioned standard products, a number of special products are either currently available or will be in the near future, including:

Merged multispectral and panchromatic data
Scene-shifted image along the satellite track
Mosaic from two adjacent scenes along the satellite track
Mosaic from four adjacent scenes
Quarter-scene film products
Large format film products
Stereoscopic pairs
Digital terrain models extracted from SPOT stereoscopic pairs
"Level 2" geometric geocoding using ground-control points and digital terrain models to remove local distortions.

48. SPOT images are particularly advantageous in erosion studies due to its superior geometric resolution and its stereo capability. SPOT panchromatic images give terrain details, while the multispectral images give information on land use, land cover and soil type. SPOT stereo pairs give topographic information. All this is essential for the assessment of soil erosion status and soil erodability.

## E. Visual interpretation of images

49. Photographic images are the cheapest and most readily available remote-sensing data. They may be acquired directly by cameras mounted on aircrafts or satellites, or produced from digital image data. Images in this form, either black and white or colour, are available for all parts of the EM spectrum accessible to remote-sensing systems.

50. Single photographs can be interpreted in two dimensions; indeed, for Landsat images, this is the only option except for small overlaps between adjacent paths. However, stereoptic viewing of overlapping photographs adds the extra dimension of relief, usually exaggerated. As well as showing topography, stereoptic viewing permits the measurement of differences in altitude and the calculation of slope angles. These factors are of great importance, both in highlighting geological features and in enabling field sites and traverses to be located accurately.

51. Interpretation of photographs for any purpose relies on several basic characteristics of the surface. These are tone, texture, pattern, shape, context and scale. These are all qualitative attributes and their use is very much a matter of experience and personal bias.

52. Aerial photographs contain a detailed record of features on the ground at the time of exposure. A photo-interpreter systematically examines the photographs and, frequently, other supporting materials such as maps and reports of field observations. Based on this study, an interpretation is made as to the physical nature of objects appearing in the photographs. Success in photo-interpretation varies with the training and experience of the interpreter, the nature of the objects being interpreted and the quality of the photographs being utilized. Generally, the most capable photo-interpreters have keen powers of observation coupled with imagination and a great deal of patience.

53. A systematic study of aerial photographs usually involves several basic characteristics of the features shown on a photograph. The exact characteristics useful for any specific task, and the manner in which they are considered, depend on the field of application.

54. At the time of the introduction of the Landsat system the expectations for practical applications, particularly in the developing countries, were quite high. The monitoring of environmental changes and inventories of natural resources in areas lacking the conventional monitoring systems of the industrialized world (i.e. ground-based systems, aircraft remote-sensing systems) was one of many important tasks to fulfil in order to cope with increased demands on the land.

55. The rather low resolution of the first image products and the vast amounts of data, however, favoured the development of computer-based data-analysis systems. When such systems were first introduced in the developing countries, their use was based on overseas technical and human resources, while local knowledge and competence concerning the land and its resources were in most cases unused. The many studies to date have been conducted by foreign experts without a concomitant education of local experts of the principles on which the technology is based. Once the foreign experts left, the training experience acquired had a limited influence on new practical applications and on the development process. There has been also an overestimation of the use of computer-assisted remote-sensing techniques and the lack of applicable results has to some extent led to a disappointment among local experts.

56. In many cases, visual interpretation of satellite images, with a knowledge of the physical process that led to them, may prove to be a preferable alternative to numerical analyses, especially in developing countries. The involvement of local expertise as well as the application of the results will be easier to achieve. The introduction of the SPOT satellite system, with a much higher resolution and the possibilities of stereo viewing, will further this approach.

57. One advantage of visual interpretation is that the same equipment can be used for conventional interpretation and mapping from aerial photographs. All developing countries have such facilities and, more important, competent staff with a good knowledge of local conditions. By contrast, many of the computer-based studies rely upon foreign equipment and foreign experts.

58. A practical application of the visual interpretation of satellite images has evolved in the developing countries because of their urgent need for rapid access to actual data for assessment of land and water resources. In most cases visual interpretation of Landsat and SPOT imagery has been based either on black-and-white images of the various spectral bands or on false colour composites (FCC). Bitemporal or multitemporal analyses are often made in order to improve the classification of the various landscape elements or monitor the annual or seasonal changes.

### F. Land-use planning and environmental monitoring

59. Space-borne remote-sensing data are a very important source for land-use planning and environmental monitoring. These data are suitable for applications on the local or regional level and also for national or global investigations. Of special interest for monitoring applications is the possibility of collecting information over large areas in a short time and of repeating the data collection at regular intervals.

60. Most of the applications in this area often have in common the need to map current conditions, natural or produced by man, to use this information to manage the natural resources of a country or region properly and to monitor the environment to avoid or reduce undesirable effects on the environment and on a country's resources.

61. Image interpretation as well as digital image processing techniques are suitable tools for the evaluation of remote-sensing data for land-use planning and environmental monitoring. The purpose and goals of a specific investigation or application problem and the available resources determine how these evaluation techniques can be used. The proper selection of appropriate data types and dates for the image collection are crucial for success in individual applications.

62. For land-use planning activities high resolution space-borne data, SPOT or the Thematic Mapper for example, provide an excellent data source that often gives more recent information on local or regional conditions than existing maps. Conversely, weather satellite data and routinely derived products, such as vegetation index maps over Africa for a 10-day or one-month period, can be suitable for national or continental monitoring of the environment, for example, of vegetation development.

## G. Land-use and vegetation mapping

63. Land use, land cover or vegetation maps provide important information on the current extent of different land uses or land covers. With remote-sensing data, at least major vegetation types and other land cover, such as bare soils, water or built-up areas, can be identified. In most cases, it is possible to deduce from the land cover and its spatial distribution specific land uses, for example agricultural or residential areas. Other land uses, for example, a national park, cannot be determined in remote-sensing data without additional information.

64. For many applications, land-cover or land-use maps do not require the same level of detail as used in agricultural or forest applications. Therefore, it is often easier to produce a useful land-cover or land-use map of a given area and often it requires less knowledge of local conditions than a detailed map of agricultural crops. Standard image-interpretation techniques are very efficient for identification and mapping of all major land-use classes. Interpretation experience from areas with similar natural conditions can reduce to a minimum the need for field checks.

65. In a typical colour infrared image, densely forested areas appear in different shades of dark red and brown, water in shades of blue, agricultural areas with lush green vegetation in shades of red and bare soils shading from blue to white. Field patterns can often be identified and provide indirect information on farm sizes and agricultural practices. Larger roads and railroads can often be identified and the distribution and development of more densely populated settlements are visible. Major topographical features such as valleys, plains and mountain ranges can be identified. Often it is possible to map and identify additional features and land properties, important for land-use planning, such as areas unsuitable for agriculture due to poor soils, excessive sloping or risk of flooding.

66. With high resolution, panchromatic SPOT data and derived maps can be used in a wide variety of ways, for example, to map within a city the road pattern, settlement types and areas, industrial areas (and sometimes even the type) and important natural conditions such as rivers, valleys or the land-cover and land-use pattern. This information can then be used to decide in which areas further settlement activities would be acceptable, which areas should be reserved for agricultural use and which natural conditions would favour or limit development.

67. In rural surroundings, typical land-cover information might outline densely forested hilly areas or plateaux, plains or river valleys with agriculture or grasslands. Often typical patterns in the distribution of different agricultural usages emerge, indicating natural limitations or favoured areas. Often these data also outline drastic differences in the state of the vegetation cover, indicating differences in agricultural practices or pressures on the land, which often result in serious degradation of the natural conditions due to over-exploitation. This information can be used to decide on necessary or possible changes in land use and to reduce negative effects of current land use.

## H. Monitoring change

68. Land use, vegetation cover and other natural conditions are not static and change with the seasons or over long periods. These changes are of interest, for example, in the follow-up of planning decisions or in verifying the efficiency of protection measures.

69. In monitoring changes it is essential that the observed differences between two images or data sets are really due to a type of change on the ground that should be monitored and that they are not produced by other effects, such as data-collection conditions. Two images of the same location, one taken during the dry season, the other near the end of the rainy season, for example, typically differ drastically in their appearance, mainly due to differences in the vegetation development and the distribution of agricultural crops. For the mapping of crop types or the monitoring of the seasonal development of vegetation, this type of information could be of great relevance. Used for monitoring the efficiency of erosion-control measures or the extent of erosion, it could result in very serious misinterpretation.

70. The use of sequences of remote-sensing data to monitor urban development or large-scale clearcutting of forests is comparatively easy and reliable. The differences between two images in these areas are typically very large and have characteristic patterns, of roads for example, that facilitate the separation of induced from natural changes. Problems occur if the affected areas are comparatively small or the change is only gradual.

71. The situation is much more critical if only small colour changes between the images are used to obtain change information. Minor differences in the weather situation during data collection, slight delays in vegetation development and the side effects of standard processing routines can result in colour differences between two scenes, even if they are taken about the same time in different years. Therefore, results based mainly on colour changes at the same time of day but on different dates, without other clear indications in the image, should be checked very carefully to avoid misinterpretation.

## I. Water-resources development and environmental monitoring

72. Remote-sensing data can be used in many ways for the development and efficient use of available water resources, which are crucial in many countries. Specific water resources, groundwater for example, can often only be indirectly mapped by remote sensing. But remote-sensing data provide many clues for the assessment of water resources, even if direct measurements are only possible in a few cases.

73. Drainage systems, catchment areas and the extent of water in major rivers and lakes can be determined from satellite data. Interpretation of types of vegetation and soil provides clues to the water available to plants, infiltration of water into the ground and expected surface run-off. In combination with weather data, this allows at least an estimate of areas with sufficient availability of water for use for different types of agriculture or grasslands. Furthermore, this information can be used to estimate the expected surface run-off and its seasonal variation within catchment areas to provide essential information for the planning of reservoirs and dams for irrigation and the production of electricity.

74. Satellite data can also be used to judge the extent and possible rate of soil erosion. Methods for a more quantitative determination of surface run-off, erosion and sedimentation rates, using remote-sensing data, are under development. Attempts within the Artemis project of the Food and Agriculture Organization of the United Nations (FAO) to estimate precipitation in Africa based on polar orbiting weather satellite data should provide interesting information on a 10-day and one-month basis. Within this project, vegetation index maps for Africa with the same time intervals are also produced.

75. High resolution data from SPOT or the Thematic Mapper can also be used to map erosion-affected or erosion-prone areas. Typically, this requires familiarity with general regional conditions and erosion processes. Additional information might be useful to differentiate various types of erosion-affected areas.

## J. Sources of radar data for remote sensing

76. Launched in July 1991, ERS-1 is a low-orbit Earth observation satellite with several microwave sensors on board. The primary mission of ERS-1 is to increase the understanding of ocean processes, to monitor the

polar regions and to contribute to the World Climatology Research Programme. However, land-oriented applications will increase as the international research community gains access to the data. The primary instrument on board ERS-1 is the Active Microwave Instrument (AMI), which can provide high-resolution images (C-band), wind speed through ocean-wave spectra analyses and the length and direction of ocean waves. Operating in the imaging mode, AMI covers a swath of 80-100 km, with an initially assessed resolution of 27 metres in range and 29 metres in azimuth.

77. Since the launch in July 1991, the ERS-1 satellite has acquired over 400,000 radar scenes. Of these, some 10,000-15,000 have been processed. In environmental applications, the all-weather advantages of ERS-1 synthetic aperture radar (SAR) for tropical, high-rainfall and equatorial regions were well to the fore.

78. The use of radar imagery in planning is still at the methods investigation stage. Problems still to be solved include the need to develop geometrical modelling, geocoding tools, mosaicking and fusion, reducing the distortion effects of relief and smoothing out speckle.

79. In the image-processing area, there is a need for dedicated tools for processing radar imagery. If segmentation based solely on ERS-1 SAR imagery fails, a radar image can be segmented using SPOT data with a cloud cover of up to 50 per cent.

80. ERS-1 SAR data are particularly useful for coverage of a large area but less so for a small area. For studying non-renewable resources, the spectral wealth of SPOT data complement the ERS-1 data as regards texture and the interpretation of morphology, particularly in areas of low relief. However, certain phenomena continue to pose interpretation problems.

81. For renewable resources, ERS-1 data combined with optical data provide more information than was anticipated. In agriculture, projects are in progress to incorporate ERS-1 data into a number of programmes. The results obtained so far demonstrate the usefulness and complementarity of radar data for discriminating and monitoring different crops. In the same way, ERS-1 data provide coverage of certain areas of tropical forest in the Amazon region, making it possible to locate and monitor deforestation.

## II. COURSE EVALUATION

82. At the conclusion of the course, the participants were asked to complete a questionnaire regarding various aspects of the content and organization of the course, including the time allotted to the topics and practical exercises as well as the relevance of the course content for their day-to-day activities. That exercise was followed by a discussion of problems of remote-sensing education in developing countries. During the discussions, the participants made a number of observations on the accomplishments of the course and recommendations for future courses.

83. All participants expressed the opinion that the general organization and planning of the presentations were of high quality. Depending on their experience and field of expertise, some participants felt that more time should have been spent on topics related to Geographic Information Systems and remote-sensing education. All the participants were of the view that the level and conduct of the course were appropriate for the specific needs of their educational and academic work.

Annex

PROGRAMME OF THE COURSE

I. INTRODUCTION

| Date | Subject | Speaker |
|---|---|---|
| Monday<br>3 May | Introductory lectures: | |
| | Centre for Space Science and Technology Education - A United Nations Initiative | A. Abiodun |
| | Remote sensing and global change | |
| | Management of natural resources and the environment - the role of remote sensing | P. Williamson<br>M. Byström |
| | Presentation of the Department of Physical Geography - education and research | W. Karlén<br>C. Christiansson<br>B. Lundén |

II. FUNDAMENTAL PRINCIPLES

| | | |
|---|---|---|
| Tuesday<br>4 May | Electromagnetic radiation, the reflective properties of the earth and elementary optics | J. Kleman |
| | Electromagnetic radiation, the reflective properties of the earth and elementary optics (continued) | J. Kleman |
| Wednesday<br>5 May | Electronic imaging | F. Quiel |
| | Electronic imaging (continued) | F. Quiel |
| | Visit to the Stockholm University Information Unit and the International Affairs Unit at the main university campus | |
| Thursday<br>6 May | Modern cartography in thematic mapping | M. Buchroithner |
| Friday<br>7 May | Earth resources and environmental satellites | M. Buchroithner |
| | Image interpretation - theory | G. Alm |
| Monday<br>10 May | The new generation of environmental satellites - the case of ERS-1 | J. Lichtenegger |

III. IMAGE INTERPRETATION

| | | |
|---|---|---|
| Monday 10 May | Lectures on the use of imagery for: | |
| | (a) Land-use planning and environmental monitoring | F. Quiel |
| | (b) Geological studies | B. Lundén |
| Tuesday 11 May | Case-studies for African, Asian and Latin American participants respectively in groups of nine | |
| Wednesday 12 May | Case-studies | |
| | AFRICA | |
| | Land degradation and soils in Lesotho | B. Lundén |
| | Land and water development in Ethiopia | R. Å. Larsson |
| | Land forms and land degradation in semi-arid Tanzania | A. Yrgård |
| | ASIA | |
| | Land degradation and soils in Lesotho | B. Lundén |
| | Environmental impact assessment of the closure of a river arm in Bangladesh | R. Å. Larsson<br>J. Nisell |
| | LATIN AMERICA | |
| | Forestry in Ecuador | R. Å. Larsson |
| | Geological applications from Central America | R. Lilljequist |
| | Land degradation and soils in Lesotho | B. Lundén |

IV. DIGITAL IMAGE PROCESSING AND ANALYSIS/GIS

| | | |
|---|---|---|
| Thursday 13 May | Digital analysis (theory) | W. Arnberg |
| | Computer enhancement (theory) | W. Arnberg |
| Friday 14 May | Geographical Information Systems (GIS) (theory) | F. Quiel |
| | GIS (theory) (continued) | F. Quiel |
| Monday 17 May | Computer-aided analysis | B. Lundén |
| | Computer-aided analysis (continued) | B. Lundén |
| Tuesday 18 May | GIS exercise | B. Lundén |
| | GIS exercise (continued) | B. Lundén |

V. REMOTE-SENSING EDUCATION AND PROJECT MANAGEMENT

| | | |
|---|---|---|
| Wednesday<br>19 May | In-service training in remote sensing in the third world | R. Å. Larsson |
| | Project management - theoretical background and brief role-play exercise | J. Valdelin |
| | Project management (continued) | J. Valdelin |

VI. REMOTE-SENSING APPLICATIONS

| | | |
|---|---|---|
| Monday<br>24 May | Introduction to the Kiruna part of the course | R. Bergström |
| | Preparation for field excursion | |
| | Field excursion. Demonstrations of image material, study of landscape feature interpretation in satellite imagery | R. Å. Larsson<br>M. Orrmalm<br>R. Bergström |
| | Presentation of Abisko Scientific Research Station and current research at the station | |
| Tuesday<br>25 May | Field work exercise. Image interpretation in groups | R. Å. Larsson<br>M. Orrmalm<br>R. Bergström |
| Wednesday<br>26 May | Group presentations of the field work | R. Å. Larsson |
| | Presentation of ESA/ESR-1 Ground segment | B. Eriksson |
| | Departure to Jukkasjärvi from where trip to Salmijärvi and Esrange satellite stations | |
| | Study visit to ESA Salmijärvi Satellite Station | |
| | Study visit to Esrange Satellite Station | |
| Thursday<br>27 May | Basic processing: Archiving, catalogue updating, standard production | J. Unga |
| | Image processing, value-added production, radiometric and geometric corrections, digital elevation model and digital terrain model extraction, ortho-image production | T. Westin |
| | Computerized cartography, production system | M. Dahlberg |
| | Study visit to Satellitbild production facilities; station-wise presentations | |

| | | |
|---|---|---|
| Friday<br>28 May | Visual interpretation of satellite images, use of imagery in project planning | M. Byström<br>H. Rasch<br>R. Bergström |
| | Visual interpretation of satellite imagery (continued) | M. Byström<br>H. Rasch<br>R. Bergström |
| Saturday<br>29 May | Visual interpretation of satellite imagery (continued) | M. Byström |
| | Visual interpretation of satellite imagery (continued) | M. Byström |
| Monday<br>31 May | Visual interpretation of satellite imagery (continued) | M. Byström |
| Tuesday<br>1 June | Group presentations of results of visual interpretation and project planning | M. Byström |
| | Group presentations of results of visual interpretation and project planning (continued) | M. Byström |

VII. NEEDS OF THE USER

| | | |
|---|---|---|
| Wednesday<br>2 June | Landsat and SPOT satellites | R. Bergström |
| | Standard and refined processed images | G. Rönnbäck |
| | Photographic end products | S. Forslund |
| | Use of enhanced images; different media; choosing the right media and products | R. Bergström |
| | Ordering Satellite Data | J. Ek |
| | Demonstrations: Customer Services Dept. | |
| | SSC projects and products | A. E. Öskog |
| | Presentation of two current projects: | |
| | (1) Land cover mapping in Malawi | U. Malmberg |
| | (2) A mapping project in Malaysia | H. Rasch |
| Thursday<br>3 June | Seminar: Future trends in remote sensing | S. W. Bie |
| | Closure of Section VI and VII | |

## VIII. SUMMARY AND EVALUATION

| | | |
|---|---|---|
| Friday<br>4 June | Swedish foreign aid | S. Pettersson |
| | Course evaluation | W. Arnberg<br>R. Bergström<br>R. Å. Larsson<br>B. Lundén<br>S. Pettersson,<br>F. Quiel<br>L. Wastenson |

UNITED NATIONS

GENERAL ASSEMBLY

Distr.
GENERAL

A/AC.105/553
19 November 1993

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

# REPORT OF THE UNITED NATIONS WORKSHOP ON SPACE COMMUNICATIONS FOR DEVELOPMENT ORGANIZED IN COOPERATION WITH THE GOVERNMENT OF GREECE

(Athens, Greece, 10-12 May 1993)

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# INTRODUCTION

## A. Background and objectives

1. On 10 December 1982, the General Assembly adopted resolution 37/90 in which it endorsed the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82). In that resolution, the Assembly decided, among other things, that the United Nations Programme on Space Applications should disseminate, through panel meetings and seminars, information on new and advanced technology and applications, particularly for the benefit of the developing countries.

2. The United Nations Workshop on Space Communications for Development was one of the activities of the Programme approved by the Committee on the Peaceful Uses of Outer Space, during its thirty-fifth session held in 1992, and subsequently endorsed by the General Assembly in resolution 37/90. The Workshop was organized following the decision of the Government of Greece to co-sponsor it as part of its contribution to United Nations activities for International Space Year, 1992. The Workshop was hosted by the Greek Ministry of Foreign Affairs through the Eugenides Foundation and the Hellenic Telecommunication Organization (OTE) at Athens, from 10 to 12 May 1993, for participants from the Mediterranean and adjacent areas.

3. The objectives of the Workshop were to provide the participants with information on the current state and future trends of satellite communications technology associated with various international and regional satellite systems and services, and its contribution to economic and social development. The Workshop also provided an opportunity for managers and specialists to exchange information on their activities in the field and to discuss possibilities for increasing international and regional cooperation.

4. The present report, which covers the background, objectives and organization of the Workshop, as well as a summary of the discussions of the participants and a summary of the technical presentations made, has been prepared for the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee. The participants will report to the appropriate authorities in their own countries.

## B. Organization and programme of the Workshop

5. The participants of the Workshop were invited in their personal capacity as experts with several years of professional experience in the fields of satellite communications, telecommunications, educational broadcasting, and in the operation and maintenance of satellite communications systems. The Workshop was attended by 47 participants from the following countries, international organizations and private companies: Albania, Algeria, Azerbaijan, Belarus, Bulgaria, Cyprus, Egypt, Germany, Greece, Israel, Lebanon, Malta, Morocco, Romania, Syrian Arab Republic, Turkey, Ukraine; Office for Outer Space Affairs, Arab Telecommunications Union (ATU), European Space Agency (ESA), European Telecommunications Satellite Organization (EUTELSAT), International Maritime Satellite Organization (INMARSAT), International Telecommunications Satellite Organization (INTELSAT), International Telecommunication Union (ITU), Hispasat, Centre for National Communication Studies (CNET); Indian Space Research Organization (ISRO), OTE; Telespazio and Alenia Spazio.

6. Funds allocated by the co-sponsors for the Workshop were used to cover the cost of international air travel and a daily subsistence allowance for the participants from developing countries; accommodation for 26 participants from developing countries as well as conference facilities and local transportation were provided by the Ministry of Foreign Affairs of Greece, the Eugenides Foundation and OTE.

7. Opening addresses were made by Mrs. V. Tsouderou, Deputy Foreign Minister of Greece on behalf of her Government, Professor D. Kouremenos, Director General of OTE and the Expert on Space Applications, Office for Outer Space Affairs of the United Nations.

8. The programme of the Workshop (see annex to the present report) was developed by the United Nations in consultation with the Ministry of Foreign Affairs of Greece and the Eugenides Foundation. The programme consisted of a series of plenary sessions and a panel discussion.

## I. OBSERVATIONS OF THE WORKSHOP

9. It was stated that the main tools in finding new applications of communications satellites for economic and social development were research and development at the national and international levels. At the same time, the realization of the benefits of space technology depended on cooperation at the international, national, particularly bilateral, and regional levels between developing countries as well as between industrialized and developing countries.

10. For the Mediterranean region and its adjacent areas, satellite systems could be an answer to regional and worldwide communications requirements. They could serve as the basis for the development of integrated terrestrial and satellite-based domestic networks.

11. Telecommunications capabilities, satellite regulations and regulatory philosophies differed from country to country and were continuously changing, creating a dynamic environment for global mobile satellite and other telecommunications operations. In view of all those changes, international satellite organizations must be flexible and willing to adapt to changing needs, particularly those of the developing countries.

12. Following political developments in Europe, there was a will to contribute towards greater European unity by cooperation in the telecommunications field. It was possible to see the promotion of a balanced telecommunications development in the Mediterranean Basin and eastern Europe.

13. Geographical conditions and demographical considerations played a role in determining the most efficient use of satellite communications; that applied for every region. For example, most Central Asian countries were land-locked countries with a rather low density population. Those countries had the classic characteristics that would benefit from the type of thin-route links that satellites could provide at lower cost than land lines. In contrast, for a densely populated country, terrestrial cellular networks were a way to bring basic telephone service to every home at a lower cost than utilizing land-line connections.

14. While a number of programmes and technical systems exist, many potential users were in the early stage of awareness of the benefits that could result from the applications of satellite communications in health, education and other government services as well as in specific actions that were part of disaster relief operations. There was a clear need to inform experts and decision makers of the necessary steps to be taken in order to benefit from the latest technological advances.

15. Among the various applications of satellite communications, particularly for developing countries, the participants identified tele-education and personal communications as those that could make substantive and cost-effective contributions to national and regional development, including economic development.

Tele-education

16. The participants evaluated the merits and problems associated with tele-education in both formal and informal education environments and concluded that it was a worthwhile goal for promoting social and economic development, particularly in remote and rural areas.

17. The participants recognized the experience of India in using satellites for formal education. However, in recommending that application, the Workshop stressed that in addition to solving the technical issues, a country interested in satellite-assisted tele-education would need to plan carefully how to reach each intended sector of its population. For that purpose, the tele-education programme should make use of community facilities, being aware of its financial implications and social impact.

18. The participants agreed that there could not be a universal solution since each country in the Mediterranean and adjacent areas differed in terms of geography and population. For Israel, being a small country and having few institutions of higher education, satellite communications could be an appropriate approach to distribute quickly results of scientific experiments from laboratories to institutions of higher education.

19. Participants from eastern European countries observed that their educational system was equipped with skilled personnel; however, it was necessary to support the education of minorities in each country, since terrestrial television distribution did not reach certain countries or did so only in parts of the large countries.

20. At the request of the Workshop, the United Nations Programme on Space Applications agreed to prepare a booklet that would focus on all aspects of tele-education, including the logistics of developing such a programme in a given country. The participants indicated that the booklet would be very useful, particularly for those countries that intended to develop a tele-education programme.

Personal communication

21. The Workshop reviewed the rapid development in personal communications and stressed the need to provide adequate information, particularly to the developing countries of the region, on that subject. The participants cautioned that development of mobile communications in a given country should not be carried out at the expense of fixed satellite communications services, particularly since most of the developers of personal communications services had not, till then, installed specific infrastructure for the new communication mode. Furthermore, the Workshop cautioned on investing in technologies that were searching for users.

Regional cooperation

22. The Workshop noted that a number of countries in the region were developing their own national satellite communications programmes. However, proliferation of such systems could result in frequency interference. That was happening in western Europe where there seemed to be a congestion of satellites. Participants expressed concern that that condition could be the same for the Mediterranean region in the immediate future. They called on their Governments to work together to devise a mechanism that would prevent that from happening.

23. The need for Member States to work together within the Arab countries as well as between the Arab and the Mediterranean countries was emphasized. Equally emphasized was the role that the European Space Agency could play in assisting the emerging countries of the former Soviet Union to improve their communications systems. The support that the Commission of European Communities could offer in that regard was also stressed.

## II. SUMMARY OF PRESENTATIONS

### A. Communications technologies for development

24. Accessible communications services were an indispensable element of global human activities. A mix of terrestrial telecommunications networks and satellite communications systems met many of the modern demands for communications. Currently, practically every country in the world benefited from a variety of communications services by participation in international, regional or domestic satellite communications systems.

25. Satellite communications technology was fully recognized as a critical tool for social and economic development. Services provided by satellite, such as telephone, radio and television broadcasting and data transmission, had enhanced a country's capabilities to provide medical attention and education to its people, particularly in rural areas, while increasing the country's cohesiveness.

26. The use of that technology had also created a healthier business climate as satellite communications continued to find commercial applications in the distribution of space-gathered data, super-computer networks, visualization of scientific and industrial processes, mobile communications services, journalism and various data services.

27. Various technological trends were combining to make satellite operations less expensive and therefore more viable to developing countries. Those trends included lower cost earth stations, compression and digital modulation techniques, and higher powered and more flexible satellites. The use of such techniques as on-board data processing, efficient networks protocols, effective monitoring and control procedures, power-efficient devices and system miniaturization could further improve the overall cost competitiveness of future satellite systems.

28. With the current pace of geopolitical, economic and technological changes in the world, a reliable and cost-effective communications network had become crucial to the achievement of increasing development goals. It had become indispensable that countries implemented telecommunications networks that enabled their industrial and scientific sectors to interact with counterparts in their country as well as in other countries in order to increase productivity.

29. For the newly independent countries, satellite systems were requirements for regional and worldwide communications. They could provide instant access to other countries and could serve as a foundation for the development of integrated terrestrial and satellite-based domestic networks.

30. The importance of the impact of satellites on tele-education could not be overemphasized. Technological developments had made satellite communications systems a powerful means for distance education and mass communication. Similarly, educators could update their knowledge of the subjects they taught and workers could be trained and re-trained through satellite-transmitted programmes in order to meet changing industrial requirements. Professionals in specialized groups used satellite systems to keep abreast of the latest developments in their field. Adult education courses delivered to homes offered lifelong learning opportunities to all. Distance education could also offer training to agriculture workers to learn new agricultural practices that could lead to establishing agro-industries, thus raising their standard of living.

### B. Mobile satellite communications

31. Mobile communications, especially mobile satellite systems was one of the most rapidly developing areas of current radio-spectrum usage. Personal mobile satellite communications were characterized by low-

cost, portable telephone and data terminals and less expensive communications charges than those traditionally associated with satellite communications.

32. In many situations, global personal mobile satellite services provided the missing link, overcoming the inherently local or regional nature of terrestrial mobile services. As a consequence, personal mobile satellite services were rapidly accelerating the growth in worldwide markets for mobile satellite communications.

33. The explosion in mobile communications markets vividly demonstrated the enormous demand for communications mobility. In many parts of the world, that demand was met by mobile satellite services. Even though cellular and personal communications networks continued to expand, economic considerations prevented their spread much beyond populated areas. Rural areas and regions of low population density, in both industrialized and developing countries, appeared destined to be either underserved or out of reach of terrestrial mobile services.

34. The Workshop noted that the INMARSAT personal satellite communications strategy, known as Project 21, was having a far-reaching impact on the ability to communicate instantly to and from anywhere on Earth. The impact was being felt both in developing and developed countries, in businesses, organizations and government administrations. There were currently about 15 million cellular telephone users worldwide. By the year 2000, that figure might increase to more than 100 million users, including cellular telephones, paging services, and aircraft and navigation communications.

35. Under Project 21, INMARSAT had introduced a family of personal mobile satellite communications services that included the following:

(a) INMARSAT C: a low-cost data service using small, inexpensive terminals about the size of a laptop computer. Introduced commercially in 1991, there were approximately 6,300 INMARSAT C terminals currently in service;

(b) INMARSAT M: a service designed to bring voice-quality communications to low-cost small terminals, including the briefcase satellite telephone. Introduced in 1992, INMARSAT M brought the advantages of satellite voice to the maritime environment;

(c) Global Satellite Paging: in 1994, INMARSAT would introduce the service to pocket-sized pagers, benefiting business executives, journalists, salespersons, couriers and travellers, who could then be contacted no matter where they were;

(d) INMARSAT P: a portable hand-held terminal that would operate with a new generation of more powerful satellites. The terminal would be introduced commercially in the period 1998-2000.

36. The Workshop noted that investment in satellite systems was growing around the world. The number and complexity of space networks notified to ITU for international coordination and recording had increased substantially. The technological developments in computer-related processing facilities and the innovations in the switching and transmission domain were associated with decreasing costs and prices, and generated both a growing demand and an increasing competition among the providers. The trend of changing from government services and monopolies to competitive communications enterprises was accompanied by varying degrees of deregulation. Telecommunication services were no longer just tariffed, stocked and connected on demand; they were marketed.

37. The increasing demands for transmission frequency allocations that the emerging mobile satellite systems would require had become a primary concern of the frequency spectrum managers. Within ITU those allocations were dealt with by the World Administrative Radio Conference (WARC). WARC had

progressively established the International Radio Regulations that were annexed to the ITU Convention. Evidence of the growing interest in mobile communications was clearly manifested in the most recent WARC held at Torremolinos, Spain, in 1992.

38. With reference to satellite communications, the Convention includes the following elements:

(a) Rights and obligations of the States in obtaining access to the frequency spectrum/satellite orbit resources;

(b) Frequency spectrum allocations to various space service categories;

(c) International recognition of the used frequency/orbit resources by the recording of frequency assignments and orbital positions in the Master International Frequency Register.

39. Within the framework of the activities of ESA, Alenia Spazio was responsible for the implementation of two payloads for mobile communications services. The European Land Mobile System (EMS) would be included on the Italsat F2 satellite and the L-band Land Mobile Payload (LLM) would be included on the Artemis satellite. EMS would provide pre-operational mobile communications for western Europe and parts of eastern Europe and North Africa; LLM would be used to promote the development of technologies for future commercial mobile communications systems. Alenia Spazio also participated in the Globalstar system, the worldwide seamless cellular satellite system that would rely on a 48-satellite constellation, with eight in-orbit spaces and would combine the use of Low Earth Orbit (LEO) satellites with existing terrestrial communications systems and Code Division Multiple Access (CDMA) techniques.

40. The current status of wireless telephone communication, especially in developed countries, relied on ground-based infrastructures, the exceptions being aeronautical and naval applications where satellite systems were currently used.

41. The ground-based approach was viable when the following main conditions were simultaneously satisfied: the existence of basic infrastructure, favourable landscape, highly populated areas and widespread welfare. Since the applicability of a ground-based wireless network was limited by the above-mentioned factors, not all potential markets would meet those conditions. As those conditions were marginally met, the commercial attractiveness of the ground-based systems decreased.

42. The global operation of a mobile satellite system required more than a worldwide satellite system and communications network. It also required an equally intricate network of international cooperation and agreements. Global services could not be successfully implemented without close, intensive and continuous cooperation and agreement from any country in which service was to be made available. That cooperation was needed to ensure permission to operate mobile terminals in national territories, provide appropriate regulatory approvals to coordinate worldwide standards and resolve frequency spectrum coordination, operational accounting and other issues. Without those mechanics for receiving international commitment and support, the planning of a worldwide global mobile satellite service could be very difficult. In western Europe, it was envisaged that due to the increasing requests for services and a favourable political situation, there would be a Pan-European system based upon the Global System for Mobiles (GSM).

### C. Domestic satellite communications

43. It was stated that the modernization of the telecommunications network had been a matter of high priority for the Government of Greece. To date, that network was based on a mixture of analogue technologies. The task of achieving the modernization of the network had been given to OTE, which to an increasing degree was turning to private industry. Within the private sector, INTRACOM, the major private

industrial company in telecommunications, telematics and electronic equipment in Greece, was the most important supplier of OTE.

44. In collaboration with major international telecommunications companies, INTRACOM designed, produced and supported Stored Program Controlled (SPC) digital exchange and provided solutions adapted to promote a telecommunications growth environment. The research and development activities of INTRACOM focused on the study and development of telecommunications software for digital switching, special type multi-function terminals, Very Large Scale Integrated (VLSI) component design, new telecommunications services and wireless communications. Active participation in major European organizations, such as the European Telecommunications Standards Institute (ETSI) and the European Association of Industries, allows INTRACOM to participate in future developments in telecommunications in the European Economic Community.

45. Spain's Hispasat Programme aimed to establish a national satellite communications system that would satisfy the future service needs of the Integrated Spanish Communications Network. In arriving at the decision to develop Hispasat, the Government of Spain and the participating industries took into account the following advantages:

(a) Strategic: the Government of Spain would be able to guarantee the continuity and stability of communications via satellite without being subject to the various interests inherent in an international organization;

(b) Technical: a footprint that was specifically adapted to Spanish territory would provide a more powerful signal, allowing for simpler reception stations with a reduced antenna-size;

(c) Economic: the Hispasat Programme would seek to guarantee product quality while procuring the greatest possible participation of its national industry.

46. Spain's Satellite Communications System was a multi-mission system programme to satisfy, in a unified way, the national needs in satellite communications. It supplied satellite capacity to transmit television images, radio and associated signals in accordance with current and future national needs. The System provided a base for special national defence communications, supplied channels for specialized data networks and provided a satellite base for television programmes addressed to the Spanish-speaking community in the Americas.

### 1. Very Small Aperture Terminals: Low-cost Earth stations

47. Very Small Aperture Terminals (VSATs) were ground-receiving antennas that offered features that could not be provided via terrestrial networks as, for example, a greater control over operations and costs of communications for specific projects or programmes. VSAT technology also provided consistency and system-design flexibility. That made a VSAT network cost predictable and easier to budget. Every ground station in the network could have the same equipment or VSATs could provide protocol conversion to allow devices with different protocols to communicate across the network. As the network size (i.e. number of VSATs) increased, the cost to provide service at each VSAT decreased.

48. In all domestic industries, the lowering of Earth station costs, while increasing service flexibility, had promoted the growth of the market for VSATs. Currently, VSATs could handle a range of voice, data and video applications, ranging from satellite news-gathering operations used by major broadcasters to low-cost data networks that provided prices of crops and agricultural supplies to isolated farmers in rural areas.

## 2. Communications in disaster-relief applications

49. The observation of Earth from space provided an invaluable means of forecasting and thus helping to prevent environmental disasters. The combination of remote sensing and communications satellites permitted the responsible agencies to effectively solve problems of distress, alert, localization of problem areas or potential problem areas as well as the possibility of monitoring redress action.

50. It was reported that in Italy, Telespazio had developed and engineered the ARGO Project, a system that provided real-time monitoring of environmental data (seismic, volcanic and hydrogeological) through 110 fixed VSATs, which were located across the national territory. In case of disaster, ARGO could restore emergency communications by means of 12 transportable stations. Both sets of facilities were connected via EUTELSAT satellites to the Operational Civil Protection Centre of Rome and to a master station at Fucino. The same type of architecture could be adapted to fulfil requirements of data collection and monitoring, and to restore emergency communications in any country or region in the world following a catastrophe.

51. Telespazio had a micro satellite system, TEMISAT, which provided collection and distribution capabilities of environmental and distress data from and to autonomous networks. The TEMISAT system was composed of three main segments:

(a) A Space Segment consisting of two micro satellites that constituted a low-cost satellite system based on a Time Division Multiple Access/Single Channel Per Carrier (TDMA/SCPC) scheme with an expected operational life of five years per satellite;

(b) A Ground Support Segment consisting of a Mission Control Centre, which processed, managed and stored the mission data and prepared the User Routing Matrix. That matrix contained the polling sequence, the synchronization and the addressee identification codes of the Earth stations;

(c) A User Segment, consisting of the User and Data Collection Centre terminals. User terminals were connected to as many as a thousand sensors and were the primary source of field data; terminals at the Data Collection Centre served to access the data for prevention or mitigation of the effects of disasters.

52. The Mediterranean Maritime Risks and Emergencies System (SERIMAR) was developed by Telespazio specifically for the timely evaluation of accident risks in the Mediterranean Sea. The SERIMAR provided decision and management support for post-disaster relief operations to minimize the economic and environmental effects of disasters as well as support for the evaluation of economic and environmental effects of disasters. For its objectives, SERIMAR utilized atmospheric, meteorological and oceanographic data, coastal-zone topography and information on port infrastructure. The data were gathered from national and international data banks as well as from coastal radars, satellite-based localization techniques (Global Positioning System) and from Earth observation satellites such as the Earth Resources Satellite (ERS-1). Thus, SERIMAR combined both the Earth observation satellites with space communications into an extremely viable tool for disaster mitigation.

## D. Regional and global telecommunications services

53. It was stated that the Mediterranean region was an area that had historically been a crossroad of civilizations and therefore an area where communications were of a particular importance. Telecommunications were starting to replace traditional communications (e.g. by land, sea and air) especially in a century in which the Mediterranean region had become a strategic area and where a highly developed North-West met a developing South-East.

54. EUTELSAT played an important role in promoting a balanced telecommunications development in the Mediterranean Basin and in eastern Europe. One of the objectives of EUTELSAT was to stress the importance of and promote access to telecommunications by satellite with a view to enhancing relations between countries and their economies as well as to promoting cooperation in that field.

55. The EUTELSAT system had been originally designed to provide full western Europe-Mediterranean coverage. However, in response to the political developments of the 1990s, the fourth and fifth versions of the EUTELSAT II satellite were modified in order to provide coverage of eastern Europe and of the Russian Federation as far as the Urals. Since January 1990, EUTELSAT membership had increased with the participation of Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Croatia, Czech Republic, Georgia, Hungary, Lithuania, Poland, Romania, Slovakia and Ukraine.

56. EUTELSAT currently operated a fleet of eight geostationary satellites. With 90 operational Ku-band transponders in orbit, EUTELSAT was the prime provider of telecommunications satellite capacity in the Euro-Mediterranean area. The fifth EUTELSAT II satellite was to be launched in December 1993, improving the coverage of eastern Europe.

57. The range of telecommunications services provided by EUTELSAT included:

(a) Telephony services: telex, facsimile and voice communications making use of Time Division Multiple Access (TDMA) technology. The participation of eastern European countries to benefit from those services was underway. In 1991, Romania had begun using the system. An Earth station was currently being tested in Poland. Croatia was planning to install a station in 1993-1994 while Azerbaijan and Bosnia and Herzegovina were planning to purchase a similar ground station;

(b) Business services: since 1986 EUTELSAT had had its Satellite Multiservices System (SMS). Direct voice and facsimile connections could be established between companies located, for example, in Morocco and the Russian Federation or between Egypt and the Ukraine. The SMS system provided a large number of communications links into central and eastern Europe;

(c) Land Mobile Services: since 1991, EUTELSAT had offered a Pan European Messaging and Positioning Service called EUTELTRACS for land mobiles. As a result, free circulation of mobile terminals was permitted in more than 20 European countries;

(d) TV/Transponders lease services: there were 35 television programmes and more than 40 radio programmes transmitted via the EUTELSAT network. The coverage reached 700 million viewers throughout Europe and the Mediterranean Basin. Since 1992, one Hungarian and two Polish channels had begun using EUTELSAT.

58. Specific action was being taken to promote the development of satellite TV in central and eastern Europe. In support of those actions, EUTELSAT was assisting in the development of a television project known as "MOSAIKA", which would assist in broadcasting programmes made in central and eastern Europe, thus contributing towards a greater cultural, economic and political integration of countries. In addition, a capacity of nine channels was being provided from Turkey and North Africa (six Turkish programmes, one Egyptian, one Moroccan and one Tunisian).

59. The role of ESA in the field of telecommunications was to promote advanced space techniques and their applications in support of European industry in space telecommunications. Currently, ESA had the following three programmes concerning fixed and mobile satellite services: (a) Olympus, which had been operational for several years; and (b) Artemis and Mercure, which were being developed. All shared a common coverage area centred in Europe. The objective of the three programmes was to experiment providing new services,

including distance learning, data distribution to remote areas and communication with mobiles. All three of those services could be of benefit to developing countries.

60. The objectives of the Olympus programmes were the development, launch and in-orbit operation of a multi-purpose platform and of an advanced series of telecommunications payloads. Those payloads were selected to advance the technology capabilities of European industry and to stimulate new-user applications. Olympus was launched in 1989 and positioned at an orbital location of 19° W. The Olympus satellite was the largest telecommunications satellite developed by ESA.

61. The utilization of Olympus had been very successful. It had provided a plethora of experiments and applications covering a wide range of fields. Through the 10/20/30 GHz Propagation Payload, the experiments (coordinated by the Olympus Propagation Experimenters group) included specific tasks such as the evaluation of data processing software, radiometry and signal attenuation. Most of the experiments were based in Europe, with one in Canada and one in the United States of America. Within the 14/12 GHz Specialized Services Payload, the experiments included Satellite-Switched Time-Division-Multiple-Access (SS-TDMA) schemes. The British Telecom, the Danish PTT and the Deutsche Bundespost were major experimenters of Olympus payloads. Other payload experiments had included high-speed data transfer from the European Organization for Nuclear Research (CERN) at Geneva to other nuclear physics research sites.

62. Still other payloads of the Olympus included the Television Broadcast Communications (TCB), with major application areas in tele-conferencing and tele-education. TCB focused on a simultaneous multi-presence video conferencing system, called the Direct Inter-Establishment Communications Experiment (DICE), allowing up to four sites to be connected simultaneously with video, audio, computer graphics and data facilities.

63. The role of a satellite-based system for mobile communications was discussed. It was clear that in terms of cost and spectrum efficiency, a satellite system could not compete with the pan-European cellular system that had started operations in 1992 in several European countries. However, a satellite system for Europe had two advantages: (a) it provided a wide area-coverage system that covered regions economically important (i.e. eastern Europe, Middle East and North Africa); and (b) it provided flexibility; that is, the ability to adopt to new and changing situations and to allow rapid implementation of new services. By the end of the century, it was expected that the Mobile Satellite System (MSS) would be integrated into the terrestrial system and would occupy a fraction of up to 10 per cent of the European mobile telecommunications market with an estimated 10-20 million users.

64. The EMS payload, to be included on the Italsat F2, would provide two-way communications between fixed Earth stations and land mobiles located in Europe and North Africa. The Italsat F2 satellite was scheduled to be launched at the end of 1994. The successor of EMS would be the LLM payload, which would be launched with Artemis for the Advanced Relay and Technology Mission in April 1996. In order to carry out land mobile communications and inter-orbit link experiments, Artemis would be positioned initially over Europe, between 6° and 19° E. Both EMS and LLM were to provide an experimental service to Europe and the adjacent regions, namely, the Mediterranean, the Middle East and the Russian Federation as far as the Urals.

65. The Mercure Programme was a global, not simply regional satellite communication system designed by European industry under the auspices of ESA. That system would allow the United Nations Environment Programme (UNEP) to monitor the global environment (i.e. changes in atmospheric composition, the climate system, water and air pollution, and deforestation). In order to do so, UNEP needed to collect, analyse and distribute environmental data to its users (regional, subregional and national centres). Considering the large amount of data involved and the distance between the centres in charge of the data acquisition and processing

and the users, a satellite-based communication infrastructure seemed the most efficient solution. That would also allow UNEP to exploit other interesting features of a satellite system, such as the possibility of transmitting the same information to all users located within the coverage of the satellite downlink antenna (broadcasting). That approach would provide ease of tailoring, required capacity in terms of satellite communications channels and above all, would require only a short time to put the system in place and make it operational.

66. The Mercure network scheduled to be operative in 1995 would have a global worldwide coverage, with the Western and Eastern hemispheres divided by an axis through Geneva and Nairobi, the European and African regional nodes acting as main traffic hub stations. A third station, located at the INTELSAT station at Leuk in Switzerland, would perform overall network control and administrative functions, such as traffic counting and billing, as well as monitoring the quality of the service. The initial implementation of the system foresaw 16 stations that, in addition to Geneva and Nairobi, would include Sioux Falls (United States of America) and São José dos Campos (Brazil), for the Western hemisphere, and Arendal (Norway), Warsaw (Poland), Kiruna (Sweden) and Bangkok (Thailand), for the Eastern hemisphere. ESA participating States would pay for the development of the system, including the network control facilities in Switzerland, and would support UNEP in its planning and implementation of the system. UNEP would bear the annual cost of operating the system.

67. Within the League of Arab States, ATU was the main body responsible for regional cooperation and international coordination of the satellite communications system in the Arab world. Its overall objectives were: to establish databases for telecommunications in the Arab countries; to conduct research and development particularly in scientific and technical education; to promote local manufacture of telecommunications equipment; to maintain an external international cooperation in the development of telecommunications; to facilitate coordination with the Arab State Broadcasting Union (ASBU) and the Arab Space Communication Satellite (ArabSat) for the optimal use of the Arab space network.

68. For the immediate future, ATU also contemplated the following goals and actions: (a) to accelerate the expansion of the telecommunications network in the region to reach an average density of 10 main lines per 100 inhabitants; (b) to provide the business community with new services while ensuring the profitability of telecommunications operations; (c) to strengthen existing communications training centres in the area; and (d) to provide assistance to the least developed Arab States in the region for the development of their telecommunications network.

## Annex

## PROGRAMME OF THE WORKSHOP

Chairperson: M. Moutsoulas (Greece)

| Date | Time | Subject | Speaker |
|---|---|---|---|
| Monday 10 May | 0900-0930 | Opening ceremony | M. Moutsoulas, Eugenides Foundation |
| | | | A. A. Abiodun, United Nations |
| | | | V. Tsouderou, Deputy Foreign Minister of Greece |
| | 0930-1000 | Opening address<br>Development of Telecommunications in Greece | D. Kouremenos, Hellenic Telecommunication Organization |
| | 1000-1030 | Keynote address<br>New communication technologies for development | M. Belfort, CNET |
| | | **Mobile satellite communications** | |
| | | Chairperson: G. Maliotis (Cyprus) | |
| | 1045-1125 | ITU new structure, WARC 92 decisions with emphasis on mobile satellite communications | G. Kovacs, ITU |
| | 1125-1215 | INMARSAT mobile satellite communications: Project 21 | G. Berzins, INMARSAT |
| | 1400-1440 | Global wireless telephone communications | M. Fargnoli, T. Sassorossi, Alenia Spazio |
| | | **Domestic satellite communication services and applications** | |
| | | Chairperson: M. El Kadiri (Morocco) | |
| | 1440-1520 | Current trend and prospects of the Hispasat system | J. A. Gibanel, Hispasat |
| | 1535-1620 | Space communications for disaster mitigation | F. Ananasso, Telespazio |

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|---|---|---|---|
| | 1620-1700 | Satellite communications for education programmes | K. Narayanan, ISRO |

Regional telecommunication services

Chairperson: M. Corciova (Romania)

| | | | |
|---|---|---|---|
| Tuesday 11 May | 0900-0940 | Regional satellite communication networks in Europe: Olympus, Artemis and Mercure programmes | A. de Agostini, ESA |
| | 0940-1020 | EUTELSAT's role in providing pan-European communications network: special emphasis on improving communications in the Mediterranean Basin and adjacent areas | A. Patacchini, EUTELSAT |
| | 1020-1100 | Communications in the Arab world: opportunities, experience and future trends | M. Abdalla, ATC |

Communications and development

Chairperson: L. Pap (Hungary)

| | | | |
|---|---|---|---|
| | 1110-1150 | Telecmedicine for space and other remote locations | C. Soulez-Lariviere, ESA |
| | 1240-1700 | Visit to INTRACOM<br><br>Presentation and visit to facilities | |

Discussions and conclusions of the Workshop

Chairperson: A. A. Abiodun (UN)

| | | | |
|---|---|---|---|
| | 0900-1200 | Panel discussions and observations of Workshop | UN |
| | 1200-1230 | Closure | A. A. Abiodun, United Nations<br><br>M. Moutsoulas, Eugenides Foundation |

UNITED NATIONS

GENERAL ASSEMBLY

Distr.
GENERAL

A/AC.105/554
26 November 1993

ORIGINAL: ENGLISH

# REPORT OF THE AD HOC INTER-AGENCY MEETING ON OUTER SPACE ACTIVITIES

(ITU Headquarters, Geneva, 11-13 October 1993)

## I. INTRODUCTION

1. The Ad Hoc Inter-Agency Meeting on Outer Space Activities was held at the headquarters of the International Telecommunication Union (ITU), from 11 to 13 October 1993. G. Kovacs of ITU was elected Chairman. For the list of participants see annex I of the present report.

2. The Secretary-General of ITU, Pekka Tarjanne, opened the Meeting and welcomed the participants. He gave an overview of the regulatory and coordinating functions of ITU relating to the use of frequency spectrum by satellites focusing on its upcoming work programme on future satellite mobile communications systems, which would culminate in its World Radiocommunication Conference in 1995. The Conference would set much of the framework for the revision of radio regulations as well as for future satellite mobile communications, which he considered to be in the vanguard of the personal communications revolution, currently under way. Noting that space technology was central to global commerce and development, to peace-keeping and disaster mitigation, to science and exploration of the universe, he stated that the United Nations family had a unique responsibility to foster cooperation and coordination towards the exploration of space for the benefit of humankind.

3. The Meeting adopted the agenda contained in annex II of the present report.

## II. SUBSTANTIVE QUESTIONS CONSIDERED AT THE MEETING

### A. Implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (agenda item 4)

### B. Coordination of plans and programmes and exchange of views on current activities in the practical applications of space technology and related areas (agenda item 5)

#### 1. Discussion of current and future plans of common interest, including consideration of the actual activities of United Nations organizations in the area of space science and technology and its applications as these relate to their mandated programmes (agenda item 5 (a))

4. It was decided to consider agenda items 4 and 5 (a) above together.

5. The Chief of the Office for Outer Space Affairs of the United Nations and the Expert on Space Applications informed the Meeting of the progress made by the Committee on the Peaceful Uses of Outer Space and its subcommittees in implementing the recommendations of the second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), and other matters of inter-agency interest. He also reported on the details concerning the relocation of the Office for Outer Space Affairs to the United Nations Office at Vienna.

6. The representatives of other organizations reported on their current activities and plans for 1994, 1995 and future years, including their efforts in connection with the implementation of the recommendations of UNISPACE 82 (A/CONF.101/10). An exchange of views followed regarding how best to coordinate future activities to implement further the relevant recommendations of UNISPACE 82. The participants noted that the organizations represented at the Meeting were continuing the implementation of those recommendations relevant to them, mostly as part of ongoing programmes.

7. The representatives also noted with appreciation the strong emphasis given by the General Assembly in its resolution 37/90 and the Committee on the Peaceful Uses of Outer Space to the importance of cooperation within the United Nations system in implementing the recommendations of UNISPACE 82. They agreed to continue giving detailed consideration to those recommendations, particularly those relating to the specialized agencies and other bodies of the United Nations system, and to keep the Committee informed of the progress made in that area.

## 2. Consideration of matters to be included in the integrated report of the Secretary-General on the programmes of work of United Nations organizations (agenda item 5 (b))

8. The Meeting had before it the draft annual report of the Secretary-General entitled "Coordination of outer space activities within the United Nations system, programmes of work for 1994, 1995 and future years". That was the nineteenth report to be submitted to the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, in which information from organizations within the United Nations system was presented in an integrated form, outlining planned activities by field of applications.

9. The participants noted that, in accordance with the agreement reached during its annual session in 1984 (see document ACC/1984/PG/8, para. 13), the draft report currently consisted of two sections: the first containing a summary of major planned activities and programmes, without reference to the organizations concerned, and the second containing a description of the future programmes of the individual organizations concerned, as in past reports.

10. The draft report contained information on activities and programmes involving the applications of space technology in the fields of remote sensing of the Earth, communications, meteorology, navigation, disaster management and other related fields. It highlighted activities carried out jointly by the organizations concerned through cooperative programmes, as well as those carried out separately within their areas of competence. Those activities ranged from assistance in education and training through fellowships, training workshops and seminars, to expert services and survey missions to the countries concerned, and the dissemination of information on the status of technology in each of the areas referred to above. The participants noted that the planned activities reflected part of the efforts of organizations to implement the recommendations of UNISPACE 82.

11. The draft report was discussed in detail, and a number of suggestions and comments were made. They would be incorporated in the final text, to be submitted by the Secretary-General to the Scientific and Technical Subcommittee at its thirty-first session, in 1994.

C. In-depth review of cooperation by organizations of the United Nations system in remote-sensing activities (agenda item 6)

12. In its consideration of the matter, the Meeting addressed a number of issues, including a brief evaluation of activities supported by the United Nations system in the developing countries. The Meeting focused on what the emphasis should be of such support in the future. Issues addressed in that context included: (a) conferences, workshops and seminars on the applications of new and advanced systems; (b) training and education programmes; (c) institution-building; (d) project formulation and execution; (e) exchange of information; and (f) other areas of inter-agency cooperation.

13. The Meeting agreed that remote sensing and Geographic Information System (GIS) technologies should be closely linked whenever appropriate. Such linking enabled integration of remote-sensing data with data from other sources, such as existing maps and ground surveys. It thus enhanced the scope of remote-sensing applications, their accuracy and cost benefits.

14. The Meeting reviewed a proposal introduced at its annual session in 1993 by the United Nations Educational, Scientific and Cultural Organization (UNESCO) to establish a series of satellite data centres (SDCs) (see annex III), and again expressed support for that concept, given that the proposal could be advanced without duplicating existing infrastructure at regional and national levels. The Meeting further expressed certain additional qualifications relating to the proposed SDCs. Those included the need to further elaborate on potential sources of funding, sources of data, types of user and data-distribution policy.

15. In that connection the Meeting had before it a working paper introduced at its annual session in 1992 by UNESCO on the question of the formatting of satellite data by the proposed SDCs. Having further discussed the working paper, the Meeting agreed to the text contained in annex III to the present report.

16. The Meeting discussed the matter of access to environmental data obtained by remote-sensing satellites and expressed its concern for the increasing tendency to restrict or qualify access to such data. The Meeting agreed that such access was a necessary condition to implementing both the recommendations of Agenda 21 adopted by the United Nations Conference on Environment and Development (UNCED) 1/ on sustainable development in developing countries and the current programmes sponsored by organizations of the United Nations system. Accordingly, the existing conditions under which data were provided to programmes sponsored by the organizations of the United Nations system should be maintained. With that in view, it was agreed that a set of requirements should be developed outlining the basis upon which data should be available to such programmes. The Meeting had had only a preliminary exchange of views at its annual session in 1992 on an informal paper outlining the requirements that had been put before it. The Meeting further discussed the question in the light of an informal paper circulated to it concerning the need to take full account of the principles relating to remote sensing of the Earth from outer space, adopted by the General Assembly in its resolution 41/65, and pointing out that the Inter-Agency Meeting should not attempt to adopt any formal document that might be seen as an attempt to revise those principles. The Meeting might, however, express its views with regard to a possible restriction of access to remote-sensing data, those data being essential for the success of the relevant United Nations programmes, and to what steps might be taken to overcome those difficulties.

17. The Meeting therefore agreed that the World Meteorological Organization (WMO) representative should review the draft paper in the light of the above-mentioned considerations and should prepare an appropriate paper for the next session of the Inter-Agency Meeting.

18. The Meeting noted with great interest the proposal to hold a World Conference on Natural Disaster Reduction (General Assembly resolution 46/149) to be organized by the Department of Humanitarian Affairs of the United Nations in connection with the International Decade for Natural Disaster Reduction (Assembly

resolution 44/236) and the Government of Japan, to be held from 23 to 27 May 1994 at Yokohama. The relevant agencies present at the Meeting would interact with the organizers of the Conference to highlight the applications of space technologies, such as remote sensing and satellite communications in disaster mitigation.

19. The Meeting commended the excellent work undertaken by the Economic and Social Commission for Asia and the Pacific/Regional Remote Sensing Programme (ESCAP/RRSP) in providing regional cooperation and coordination in the field of remote sensing and GIS. Noting the increasing use of remote sensing and GIS for sustainable development and the interest of the States of that region for continued promotion and coordination of regional remote-sensing activities, the Meeting expressed its strong support for strengthening the ESCAP/RRSP activities. In that connection, the Meeting expressed its support for the establishment of a permanent section on remote sensing and GIS in the ESCAP secretariat as recommended by the Committee on Environment and Sustainable Development (E/ESCAP/ESD/REP) at its first session, held at Bangkok, Thailand from 4 to 8 October 1993.

20. The Meeting also noted with great interest the preparations for the Asia-Pacific Ministerial Level Meeting on space applications for development in the ESCAP region, organized by ESCAP, to be held on 23 and 24 September 1994 at Beijing. It was further agreed that the preparatory work under way for the proposed meeting should take into account the ongoing work relating to the establishment of the proposed United Nations regional centre for space science and technology education in the ESCAP region.

21. The Meeting noted with interest the remote-sensing activities undertaken by the Economic Commission for Africa (ECA) including those carried out by the regional and subregional centres sponsored by ECA, and it expressed strong support for strengthening those activities.

22. The Meeting agreed that the discussions during the course of its consideration of the matters relating to remote sensing had identified several important points to be discussed at future meetings. It was noted that discussions should continue on those points and other selected issues because, unlike other emerging areas of technology, such as space manufacturing, the benefits of which were not yet apparent as far as developing countries were concerned, remote sensing was definitely an important tool for developing countries. Further, it was noted that, while many agencies and organizations of the United Nations system were interested in remote-sensing activities, including relevant early warning activities, there was no coordinated mechanism responsible for remote-sensing activities as a whole, apart from the Ad Hoc Inter-Agency Meeting on Outer Space Activities.

23. Therefore, the Meeting agreed that the in-depth review of the cooperation of organizations of the United Nations system in remote-sensing and related GIS activities should be continued at its next session. In that connection, the Meeting decided that the matters of inter-agency concern should be further reviewed at its next session.

## III. FUTURE PROGRAMME OF WORK

24. The Ad Hoc Inter-Agency Meeting on Outer Space Activities, which provided an efficient platform and mechanism for organizations and agencies of the United Nations system to cooperate in promoting the peaceful uses of space technologies, could offer to serve as a coordinating body for inter-agency preparations of the proposed UNISPACE-3 conference.

25. The Meeting reiterated the importance of continuing its meetings on an annual basis, in order to better coordinate activities relating to outer space within the United Nations system. In that connection, the Meeting also noted that, owing to the work carried out by the Inter-Agency Meeting, the concerns expressed by

various intergovernmental committees, particularly the Committee on the Peaceful Uses of Outer Space, relating to the duplication of efforts in the work of various organizations of the United Nations system, had been satisfactorily dealt with and that those committees had positively commented on the work of the Inter-Agency Meeting in their recent reports.

26. The Meeting, noting the recommendation of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space concerning the necessity of ensuring continuous and effective consultations and coordinations in the field of outer space activities among organizations within the United Nations system and the avoidance of duplication of activities (A/AC.105/543, para. 39), agreed that the present report should be brought to the attention of the Subcommittee in response.

27. The participants considered the need for further inter-agency consultation on, and coordination of, the activities and programmes of the organizations of the United Nations system, particularly in view of the implementation of the recommendations of UNISPACE 82 and the follow-up activities to be undertaken in response to Agenda 21. 1/ The participants therefore agreed that the next Ad Hoc Inter-Agency Meeting on Outer Space Activities should be held with the following major items on its provisional agenda:

1. Implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space and review of preparations for UNISPACE-3.

2. Implementation of the recommendations of Agenda 21.

3. Coordination of plans and programmes and exchange of views on current activities in the practical application of space technology and related areas:

   (a) Discussion of current and future plans of common interest, including consideration of the actual activities of United Nations organizations in the area of space science and technology and its applications as they relate to their mandated programmes;

   (b) Consideration of matters to be included in the report of the Secretary-General on the programme of work of United Nations organizations.

4. In-depth review of the cooperation of United Nations organizations in remote-sensing and related GIS activities: remote-sensing data policy for requirements of the organizations of the United Nations system.

5. Coordination of follow-up activities of the organizations of the United Nations system for International Space Year 1992.

6. Other matters.

28. The participants agreed that they should continue their in-depth review of cooperation between United Nations organizations in some specific areas of space applications, such as communications, navigation, meteorology and related technology transfer, education and spin-off benefits, in order to ensure that the activities of the United Nations system in those areas were meaningfully integrated and the services rendered to Member States fully met their requirements in an efficient and cost-effective manner.

29. In view of the importance of the ongoing review process, the participants considered it essential that all organizations concerned, particularly those dealing with remote sensing, should attend the next Ad Hoc Inter-Agency Meeting on Outer Space Activities.

30. Because most of the participating organizations were based in Europe, and considering that the Office for Outer Space Affairs had been relocated to Vienna, the Meeting agreed that the next session of the Inter-Agency Meeting should be convened in Vienna. Considering that interested agencies would be represented at meetings of the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee, which henceforth would be convened in Vienna, it was agreed that the sessions of the Inter-Agency Meeting should be convened in conjunction with sessions of the Scientific and Technical Committee. Considering, however, that the time between the present meeting and the next session of the Scientific and Technical Meeting would not allow for sufficient preparations for the next Inter-Agency Meeting, it was agreed that the 1994 session of the Inter-Agency Meeting should be convened in conjunction with the Committee in June 1994 on the understanding that the 1995 session would be held in conjunction with that of the Scientific and Technical Subcommittee in February 1995. The above-mentioned agreement was without prejudice to any invitation by an interested agency to host a future session at its headquarters.

## IV. OTHER MATTERS

31. During the course of the Meeting a technical presentation of the Global Emergency Observation and Warning (GEOWARN) Project was made by the representative of the European Space Agency (ESA) on behalf of the International Space University (ISU), elaborating on the results of a design project carried out by an international group of graduate students during the 1993 summer session of ISU, held at Huntsville, Alabama, United States of America, resulting in a system design proposal that was a contribution to the International Decade for Natural Disaster Reduction. The participants raised several issues, which were clarified by the ISU presenters, and the Meeting agreed that it was worthwhile to examine it closer. Accordingly, it was recommended that the design project should be submitted formally for comment and consideration by the specialized agencies of the United Nations.

32. The attention of the Meeting was drawn to the proposed exhibition to be housed at the United Nations Office at Vienna, Vienna International Centre (VIC), emphasizing international cooperation in space activities of Member States, specialized agencies of the United Nations system and other international organizations. The exhibition would begin in 1994. Representatives of several agencies indicated that they would be sending material for the exhibit and others were encouraged to do so. It was stated that the VIC was visited annually by over 75,000 visitors.

33. The Meeting expressed its appreciation to Z. D. Kalensky, Head of the FAO remote sensing centre, who was retiring from FAO, for the outstanding work carried out through FAO remote-sensing activities and for the services rendered over many years to the Inter-Agency Meeting, particularly during his chairmanship.

34. The Meeting expressed its gratitude to ITU for acting as host. The Meeting also expressed its appreciation to the Chairman as well as to the Office for Outer Space Affairs and its chief for the preparations and the secretariat support of the meetings, which contributed significantly to the strengthening of cooperation within the United Nations system.

## Note

1/ Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992 (A/CONF.151/26/Rev.1 (Vol. I and Vol. I/Corr.1, Vol. II, Vol. III and Vol. III/Corr.1)) (United Nations publication, Sales No. E.93.1.8 and corrigenda), vol. I: Resolutions adopted by the Conference, resolution 1, annex II.

## Annex I

## LIST OF PARTICIPANTS

Chairman: G. KOVACS (International Telecommunication Union)

Secretary: N. JASENTULIYANA (United Nations)

| | |
|---|---|
| **United Nations** | |
| Office for Outer Space Affairs | A. A. Abiodun |
| Economic Commission for Africa | O. Nino-Fluck |
| Economic and Social Commission for Asia and the Pacific | He Changchui |
| United Nations Development Programme | K. Von Vietinghoff |
| United Nations Environment Programme | R. G. Witt |
| **Specialized agencies** | |
| Food and Agriculture Organization of the United Nations | Z. D. Kalensky |
| United Nations Educational, Scientific and Cultural Organization | R. Missotten |
| United Nations Industrial Development Programme | A. Akpa |
| World Health Organization | Kh. Shibib |
| World Meteorological Organization | E. Sarukhanian<br>J. M. Rainer |
| International Telecommunication Union | H. Meyerhoff<br>A. Nalbandian |
| **Other organizations** | |
| International Space University<br>(For technical presentation only.) | E. Slachmylders (ESA)<br>R. Bunce (ISU) |

## Annex II

## AGENDA

1. Opening of the Meeting.

2. Election of the Chairman of the Meeting.

3. Adoption of the agenda.

4. Implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space.

5. Coordination of plans and programmes and exchange of views on current activities in the practical applications of space technology and related areas:

   (a) Discussion of current and future plans of common interest, including consideration of the actual activities of United Nations organizations in the area of space science and technology and its applications as they relate to their mandated programmes;

      (i) United Nations Space Applications Programmes;
      (ii) Programmes of the other organizations;

   (b) Consideration of matters to be included in the integrated report of the Secretary-General on the programmes of work of United Nations organizations.

6. In-depth review of the cooperation of organizations in the United Nations system in remote-sensing activities.

7. Review and coordination of follow-up activities of the organizations of the United Nations system on International Space Year, 1992.

8. Other matters:

   (a) Future meetings;

   (b) Others;

      (i) Third UNISPACE conference;
      (ii) Additional matters.

## Annex III

### FORMATTING OF SATELLITE DATA BY THE PROPOSED SATELLITE DATA CENTRES

The available data should be in "user-friendly" format(s) in two aspects:

The first concern is to make available to potential users the information concerning existing satellite data sets, be it at a continental, regional, national or subnational level. This means providing users with "meta-data", presumably in a database, so that they can examine the relevant information on-line in a sort of electronic data catalogue.

The second concern is to provide the actual satellite data in a form which is readily usable. This implies a certain amount of re-formatting by the proposed "Satellite Data Centres" (SDCs), before the data can be passed on to potential users. Satellite data could also be geo-referenced for further use within a geographic information system (GIS).

The goals mentioned above will involve significant work of ever-increasing magnitude. The following is a list of the simplest to the most difficult tasks implied by the above.

1. Entry of satellite data descriptive attributes to:

   (a) Some list (analogue form, as a minimum);

   (b) Electronic catalogue;

   (c) Database format.

2. Pre-processing of satellite data:

   (a) Re-formatting from original tapes to other medium or media (hard disk, diskette, CD-ROM etc.);

   (b) Re-formatting to "simpler" formats for users; e.g. so-called flat files and/or data subsets;

   (c) Application of specific algorithms to original, raw parameters (veg. index) etc.

3. Geo-coding of satellite data:

   (a) Geometric corrections;

   (b) Precision geo-referencing to some agreed upon coordinate system; e.g. latitude/longitude.

4. Entry of satellite data to GIS.